

In the claims:

Amend claims 1-46 where indicated.

1 1. (Currently Amended) In a magnetic read head having an air bearing surface
2 (ABS), a magnetic tunnel junction (MTJ) sensor for connection to sense circuitry for detecting
3 changes in electrical resistance within the sensor, the sensor comprising:

4 a MTJ stack with an active region disposed at the ABS and having ~~two opposite~~ oppositely
5 facing first and second sides each disposed generally orthogonally to the ABS, the MTJ stack
6 comprising:

7 an antiferromagnetic (AFM) layer spanning the active region,

8 a pinned layer of ferromagnetic (FM) material in contact with the AFM layer,

9 a free layer of FM material spanning the active region and ~~extending beyond each~~
10 ~~of the two opposite sides thereof, and~~ having first and second free layer extensions which
11 extend in opposite directions from the first and second sides respectively;

12 a tunnel junction layer of electrically nonconductive material disposed between the
13 pinned layer and the free layer in the active region; [[and]]

14 the AFM, pinned, free and tunnel junction layers having parallel surfaces which
15 extend between the first and second sides and are orthogonal with respect to the ABS; and

16 the first and second free layer extensions having first and second top surfaces
17 which are parallel with respect to the parallel surfaces of the AFM, pinned, free and tunnel
18 junction layers;

19 [[a]] first and second longitudinal bias [[layer]] layers formed on and in contact with the
20 ~~free layer~~ first and second top surfaces of the free layer extensions outside of the active region for
21 biasing the magnetic moment of the free layer in substantially a predetermined direction in the
22 absence of an external magnetic field.

1 2. (Currently Amended) The sensor of claim 1 further comprising:

2 an insulating layer of electrically nonconductive material formed on and in contact with
3 the free layer extensions outside of the active region and in abutting contact with the ~~two opposite~~
4 first and second sides of the active region.

1 3. (Original) The sensor of claim 2 wherein the longitudinal bias layer is disposed
2 without contacting the active region.

1 4. (Original) The sensor of claim 3 wherein the longitudinal bias layer comprises
2 a hard magnetic (HM) material.

1 5. (Withdrawn) The sensor of claim 3 wherein the longitudinal bias layer comprises
2 an AFM material.

1 6. (Original) The sensor of claim 1 wherein the longitudinal bias layer is disposed
2 without contacting the active region.

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contd*
2 7. (Original) The sensor of claim 6 wherein the longitudinal bias layer comprises
a HM material.

1 8. (Withdrawn) The sensor of claim 6 wherein the longitudinal bias layer comprises
2 an AFM material.

1 9. (Withdrawn) The sensor of claim 1 further comprising:
2 the longitudinal bias layer comprises an electrically nonconductive AFM material disposed
3 outside of the active region and in abutting contact with the two opposite sides of the active
4 region.

1 10. (Withdrawn) The sensor of claim 1 wherein the longitudinal bias layer comprises
2 an electrically nonconductive HM material disposed outside of the active region and in abutting
3 contact with the two opposite sides of the active region.

1 11. (Currently Amended) A direct access storage device (DASD) comprising:
2 a magnetic recording disk having at least one surface for storing magnetically recorded
3 data;
4 a magnetic read head having an air bearing surface (ABS) disposed for reading the data
5 from the magnetic recording disk surface;

6 in the magnetic read head, a magnetic tunnel junction (MTJ) sensor comprising:

7 a MTJ stack with an active region disposed at the ABS and having ~~two opposite~~
8 oppositely facing first and second sides each disposed generally orthogonally to the ABS,
9 the MTJ stack comprising:

10 an antiferromagnetic (AFM) layer spanning the active region,

11 a pinned layer of ferromagnetic (FM) material in contact with the AFM
12 layer,

13 a free layer of FM material spanning the active region and ~~extending~~
14 ~~beyond each of the two opposite sides thereof, and~~ having first and second free
15 layer extensions which extend in opposite directions from the first and second
sides respectively;

16 a tunnel junction layer of electrically nonconductive material disposed
17 between the pinned layer and the free layer in the active region; [[and]]

18 the AFM, pinned, free and tunnel junction layers having parallel surfaces
19 which extend between the first and second sides and are orthogonal with respect
20 to the ABS; and

21 the first and second free layer extensions having first and second top
22 surfaces which are parallel with respect to the parallel surfaces of the AFM,
23 pinned, free and tunnel junction layers;

24 [[a]] first and second longitudinal bias [[layer]] layers formed on and in contact with the
25 ~~free layer~~ first and second top surfaces of the free layer extensions outside of the active region for
26 biasing the magnetic moment of the free layer in substantially a predetermined direction in the
27 absence of an external magnetic field;

28 an actuator for moving the magnetic read head across the magnetic recording disk surface
29 to access the data stored thereon; and

30 a data channel having sense circuitry coupled electrically to the MTJ sensor for detecting
31 changes in resistance of the MTJ sensor caused by rotation of the magnetic moment of the free
32 ferromagnetic layer relative to the fixed magnetic moment of the pinned layer responsive to
33 magnetic fields representing the data stored on the ~~magnet~~ magnetic recording disk surface.
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1 12. (Currently Amended) The DASD of claim 11 further comprising:
2 an insulating layer of electrically nonconductive material formed on and in contact with the free
3 layer outside of the active region and in abutting contact with the [[two]] first and second opposite
4 sides of the active region.

1 13. (Original) The DASD of claim 12 wherein the longitudinal bias layer is
2 disposed without contacting the active region.

1 14. (Original) The DASD of claim 13 wherein the longitudinal bias layer
2 comprises a hard magnetic (HM) material.

AT cont'd
2 15. (Withdrawn) The DASD of claim 13 wherein the longitudinal bias layer
2 comprises an AFM material.

1 16. (Original) The DASD of claim 11 wherein the longitudinal bias layer is
2 disposed without contacting the active region..

1 17. (Original) The DASD of claim 16 wherein the longitudinal bias layer
2 comprises a HM material.

1 18. (Withdrawn) The DASD of claim 16 wherein the longitudinal bias layer
2 comprises an AFM material.

1 19. (Withdrawn) The DASD of claim 11 further comprising:
2 the longitudinal bias layer comprises an electrically nonconductive AFM material disposed outside
3 of the active region and in abutting contact with the two opposite sides of the active region.

1 20. (Withdrawn) The DASD of claim 11 wherein the longitudinal bias layer
2 comprises an electrically nonconductive AFM material disposed outside of the active region and
3 in abutting contact with the two opposite sides of the active region.

1 21. (Withdrawn) In a magnetic read head having an air bearing surface (ABS), a
2 magnetic tunnel junction (MTJ) sensor for connection to sense circuitry for detecting changes in
3 electrical resistance within the sensor, the sensor comprising:

4 a MTJ stack with an active region disposed at the ABS and having two opposite sides each
5 disposed generally orthogonally to the ABS, the MTJ stack comprising:

6 an antiferromagnetic (AFM) layer spanning the active region,

7 a pinned layer of ferromagnetic (FM) material in contact with the AFM layer,

8 a free layer of FM material spanning the active region, and

9 a tunnel junction layer of electrically nonconductive material disposed between the
10 pinned layer and the free layer in the active region; and

11 a nonconductive longitudinal bias layer formed outside of the active region and in abutting
12 contact with the two opposite sides of the active region for biasing the magnetic moment of the
13 free layer in substantially a predetermined direction in the absence of an external magnetic field.

14 22. (Withdrawn) The sensor of claim 21 wherein the nonconductive longitudinal bias
15 layer comprises a hard magnetic (HM) material.

16 23. (Withdrawn) A direct access storage device (DASD) comprising:

1 a magnetic recording disk having at least one surface for storing magnetically recorded
2 data;

3 a magnetic read head having an air bearing surface (ABS) disposed for reading the data
4 from the magnetic recording disk surface;

5 in the magnetic read head, a magnetic tunnel junction (MTJ) sensor comprising:

6 a MTJ stack with an active region disposed at the ABS and having two opposite
7 sides each disposed generally orthogonally to the ABS, the MTJ stack comprising:

8 an antiferromagnetic (AFM) layer spanning the active region,

9 a pinned layer of ferromagnetic (FM) material in contact with the AFM layer,

10 a free layer of FM material spanning the active region, and

11 a tunnel junction layer of electrically nonconductive material disposed between the
12 pinned layer and the free layer in the active region; and

13 a nonconductive longitudinal bias layer formed outside of the active region and in abutting
14 contact with the two opposite sides of the active region for biasing the magnetic moment of the
15 free layer in substantially a predetermined direction in the absence of an external magnetic field;
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17 an actuator for moving the magnetic read head across the magnetic recording disk surface
18 to access the data stored thereon; and

19 a data channel having sense circuitry coupled electrically to the MTJ sensor for detecting
20 changes in resistance of the MTJ sensor caused by rotation of the magnetic moment of the free
21 ferromagnetic layer relative to the fixed magnetic moment of the pinned layer responsive to
22 magnetic fields representing the data stored on the magnetic recording disk surface.

1 24. (Withdrawn) The sensor of claim 23 wherein the nonconductive longitudinal bias
2 layer comprises a hard magnetic (HM) material.

1 25. (Withdrawn) A method for fabricating a magnetic tunnel junction (MTJ) sensor
2 for use in a magnetic read head having an air bearing surface (ABS), the method comprising the
unordered steps of:

3 (a) forming a MTJ stack with an active region disposed at the ABS and having two
4 opposite sides each disposed generally orthogonally to the ABS, including the unordered steps of:

5 (a.1) forming an antiferromagnetic (AFM) layer,

6 (a.2) forming a pinned layer of ferromagnetic (FM) material in contact with the AFM
7 layer,

8 (a.3) forming a free layer of FM material,

9 (a.4) forming a tunnel junction layer of electrically nonconductive material disposed
10 between the pinned layer and the free layer, and

11 (a.5) removing all material outside of the active region from the AFM layer, the pinned
12 layer, and the tunnel junction layer to define the two opposite sides of the active region; and

13 (b) forming a longitudinal bias layer outside of the active region in contact with the
14 free layer for biasing the magnetic moment of the free layer in substantially a predetermined
15 direction in the absence of an external magnetic field.
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1 26. (Withdrawn) The method of claim 25 further comprising the step of:

2 (c) forming an insulating layer of electrically nonconductive material on and in contact
3 with the free layer outside of the active region and in abutting contact with the two opposite sides
4 of the active region.

1 27. (Withdrawn) The method of claim 26 wherein the longitudinal bias layer is
2 disposed without contacting the active region.

1 28. (Withdrawn) The method of claim 27 wherein the longitudinal bias layer
2 comprises a hard magnetic (HM) material.

1 29. (Withdrawn) The method of claim 27 wherein the longitudinal bias layer
2 comprises an AFM material.

1 30. (Withdrawn) The method of claim 25 wherein the longitudinal bias layer is
2 disposed without contacting the active region.

1 31. (Withdrawn) The method of claim 30 wherein the longitudinal bias layer
2 comprises a HM material.

1 32. (Withdrawn) The method of claim 30 wherein the longitudinal bias layer
2 comprises an AFM material.

1 33. (Withdrawn) The method of claim 25 wherein the forming step (b) further
2 comprises the step of:

3 (b.1) forming a nonconductive longitudinal bias layer outside of the active region and
4 in abutting contact with the two opposite sides of the active region for biasing the magnetic
5 moment of the free layer in substantially a predetermined direction in the absence of an external
6 magnetic field.

1 34. (Withdrawn) The sensor of claim 33 wherein the nonconductive longitudinal bias
2 layer comprises a HM material.

1 35. (Withdrawn) The sensor of claim 33 wherein the nonconductive longitudinal bias
2 layer comprises an AFM material.

1 36. (Withdrawn) The method of claim 25 wherein the removing step (a.5) further
2 comprises the step of:

3 (a.5.1) removing all material outside of the active region from the AFM layer, the pinned
4 layer, the tunnel junction layer and the free layer to define the two opposite sides of the active
5 region.

1 37. (Withdrawn) The method of claim 36 wherein the forming step (b) further
2 comprises the step of:

3 (b.1) depositing additional FM material on the free layer in the active region and beyond
4 the two opposite sides of the active region.

1 38. (Withdrawn) The method of claim 37 further comprising the step of:
2 (c) forming an insulating layer of electrically nonconductive material on and in contact
3 with the free layer outside of the active region and in abutting contact with the two opposite sides
4 of the active region.

1 39. (Withdrawn) The method of claim 38 wherein the longitudinal bias layer is
2 disposed without contacting the active region.

1 40. (Withdrawn) The method of claim 39 wherein the longitudinal bias layer
comprises a hard magnetic (HM) material.

2 41. (Withdrawn) The method of claim 39 wherein the longitudinal bias layer
comprises an AFM material.

1 42. (Withdrawn) The method of claim 37 wherein the longitudinal bias layer is
2 disposed without contacting the active region.

1 43. (Withdrawn) The method of claim 42 wherein the longitudinal bias layer
2 comprises a HM material.

1 44. (Withdrawn) The method of claim 42 wherein the longitudinal bias layer
2 comprises an AFM material.

1 45. (Withdrawn) The method of claim 36 wherein the forming step (b) further
2 comprises the step of:

3 (b.1) forming a nonconductive longitudinal bias layer outside of the active region and
4 in abutting contact with the two opposite sides of the active region for biasing the magnetic
5 moment of the free layer in substantially a predetermined direction in the absence of an external
6 magnetic field.

1 46. (Withdrawn) The method of claim 45 wherein the nonconductive longitudinal
2 bias layer comprises a hard magnetic (HM) material.

Add new claims 47-52.

1 47. (New) A magnetic tunnel junction sensor, which has an air bearing surface
2 (ABS), comprising:
3 a ferromagnetic pinned layer having a magnetic moment;
4 an antiferromagnetic (AFM) pinning layer exchange coupled to the pinned layer for
5 pinning the magnetic moment of the pinned layer perpendicular to the ABS;
6 a ferromagnetic free layer having a magnetic moment parallel to the ABS;
7 a nonconductive and nonmagnetic spacer layer located between the free and pinned layers;
8 each of the AFM, pinned, spacer and free layers having first and second side surfaces
9 which are orthogonal with respect to the ABS with the first side surfaces of the AFM, pinned
10 spacer and free layers being contiguous and the second side surfaces of the AFM, pinned, spacer
11 and free layers being contiguous;
12 each of the AFM, pinned, spacer and free layers having major thin film surfaces which
13 extend between the first and second side surfaces, are orthogonal with respect to the ABS and are
14 parallel with respect to one another;
15 the free layer having laterally extending first and second side extensions which extend in
16 opposite directions from the first and second side surfaces respectively of the free layer with each
17 of the first and second side extensions having a top surface which is orthogonal with respect to the
18 ABS and parallel with respect to said major thin film surfaces;
19 first and second longitudinal bias layers interfacing the top surfaces of the first and second
20 side extensions and spaced from the first and second side surfaces respectively of the free layer
21 so as to leave first and second top surface portions respectively between the first and second
22 longitudinal bias layers and the first and second side surfaces respectively of the free layer which
23 are not interfaced by the first and second longitudinal bias layers; and
24 nonconductive and nonmagnetic first and second insulation layers interfacing the first and
25 second side surfaces respectively of the AFM, pinned, spacer and free layers, the first and second
26 top surface portions respectively and the first and second longitudinal bias layers respectively.

1 48. (New) The sensor as claimed in claim 47 wherein the first and second
2 longitudinal bias layers are composed of a hard magnetic material.

49. (New) A magnetic read head, which has an air bearing surface (ABS), comprising:
first and second lead layers;
a magnetic tunnel junction (MTJ) sensor located between and in electrical contact with the
first and second lead layers;
the MTJ sensor comprising:
a ferromagnetic pinned layer having a magnetic moment;
an antiferromagnetic (AFM) pinning layer exchange coupled to the pinned layer
for pinning the magnetic moment of the pinned layer perpendicular to the ABS;
a ferromagnetic free layer having a magnetic moment parallel to the ABS;
a nonconductive and nonmagnetic spacer layer located between the free and pinned
layers;
each of the AFM, pinned, spacer and free layers having first and second side
surfaces which are orthogonal with respect to the ABS with the first side surfaces of the
AFM, pinned spacer and free layers being contiguous and the second side surfaces of the
AFM, pinned, spacer and free layers being contiguous; and
each of the AFM, pinned, spacer and free layers having major thin film surfaces
which extend between the first and second side surfaces, are orthogonal with respect to the
ABS and are parallel with respect to one another;
first and second longitudinal bias layers interfacing the top surfaces of the first and second
side extensions and spaced from the first and second side surfaces respectively of the free layer
so as to leave first and second top surface portions respectively between the first and second
longitudinal bias layers and the first and second side surfaces respectively of the free layer which
are not interfaced by the first and second longitudinal bias layers; and
nonconductive and nonmagnetic first and second insulation layers interfacing the first and
second side surfaces respectively of the AFM, pinned, spacer and free layers, the first and second
top surface portions respectively and the first and second longitudinal bias layers respectively.

50. (New) The magnetic head as claimed in claim 49 wherein the first and second
longitudinal bias layers are composed of a hard magnetic material.

1 51. (New) A direct access storage device (DASD) comprising:
2 a magnetic recording disk having at least one surface for storing magnetically recorded
3 data;
4 a magnetic read head having an air bearing surface (ABS) disposed for reading the data
5 from the magnetic recording disk surface;
6 in the magnetic read head, a magnetic tunnel junction (MTJ) sensor comprising:
7 a ferromagnetic pinned layer having a magnetic moment;
8 an antiferromagnetic (AFM) pinning layer exchange coupled to the pinned layer
9 for pinning the magnetic moment of the pinned layer perpendicular to the ABS;
10 a ferromagnetic free layer having a magnetic moment parallel to the ABS;
11 a nonconductive and nonmagnetic spacer layer located between the free and pinned
12 layers;
13 each of the AFM, pinned, spacer and free layers having first and second side
14 surfaces which are orthogonal with respect to the ABS with the first side surfaces of the
15 AFM, pinned spacer and free layers being contiguous and the second side surfaces of the
16 AFM, pinned, spacer and free layers being contiguous;
17 each of the AFM, pinned, spacer and free layers having major thin film surfaces
18 which extend between the first and second side surfaces, are orthogonal with respect to the
19 ABS and are parallel with respect to one another; and
20 the free layer having laterally extending first and second side extensions which
21 extend in opposite directions from the first and second side surfaces respectively of the
22 free layer with each of the first and second side extensions having a top surface which is
23 orthogonal with respect to the ABS and parallel with respect to said major thin film
24 surfaces;
25 first and second longitudinal bias layers interfacing the top surfaces of the first and second
26 side extensions and spaced from the first and second side surfaces respectively of the free layer
27 so as to leave first and second top surface portions respectively between the first and second
28 longitudinal bias layers and the first and second side surfaces respectively of the free layer which
29 are not interfaced by the first and second longitudinal bias layers;
30 nonconductive and nonmagnetic first and second insulation layers interfacing the first and
31 second side surfaces respectively of the AFM, pinned, spacer and free layers, the first and second
32 top surface portions respectively and the first and second longitudinal bias layers respectively;

33 an actuator for moving the magnetic read head across the magnetic recording disk surface
34 to access the data stored thereon; and

35 a data channel having sense circuitry coupled electrically to the MTJ sensor for detecting
36 changes in resistance of the MTJ sensor caused by rotation of the magnetic moment of the free
37 ferromagnetic layer relative to the fixed magnetic moment of the pinned layer responsive to
38 magnetic fields representing the data stored on the magnet recording disk surface.

1 52. (New) The sensor as claimed in claim 51 wherein the first and second
2 longitudinal bias layers are composed of a hard magnetic material.
